

Silicon-on-Diamond: An Engineered Substrate for Electronic Applications

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Silicon on Diamond (SOD) is a substrate material engineered to address the major challenges of silicon-based VLSI-technology in particular thermal management and charge confinement. In the present SOD-concept, this is achieved by joining a single crystalline Si-layer (device-layer) suitable for the fabrication of IC's with a highly oriented polycrystalline diamond (HOD) layer that serves as an electrical insulator, a heat spreader and a substrate. Therefore SOD represents an alternative SOI concept, where the thermally insulating SiO₂ is replaced by highly thermally conductive diamond.

First experiments and simulations aimed at the assessments of thermal management properties of fabricated SOD wafers were made and compared to Si and SOI. Two experimental methods were used to achieve this task, direct measurements of the temperature of metallic micro-strip heaters by exploiting their thermally dependent conductivity and thermal imaging of micro-strip heaters by using an IR-CCD camera. The theoretical assessment was performed by finite element modeling (FEM) of micro-strip heaters on Si, SOI and SOD. The results of the measurements are in good agreement with the values obtained by FEM and show that SOD can sustain >15-times higher power inputs than SOI, which translates into a ~4 times higher integration density of devices on SOD.

After validating the primary benefits of SOD, namely its superior thermal management properties, the second task is to show device operation on SOD and compare the operation of these devices with respect to SOI. In addition the analysis of the interface properties between the Si-device layer and diamond is important to understand the operation of devices on SOD and their limitations. For this reason MESFETs and Schottky diodes are fabricated on the SOD and SOI wafer simultaneously, which will allow for a complete electrical analysis of the SOD concept and a direct comparison with the SOI technology. Evaluation of these first electronic devices on SOD wafers and a comparison to devices fabricated on SOI will be presented.